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**DESIGN AND CONSTRUCTION OF A CONVERTIBLE HEMI/ANECHOIC  
ACOUSTICAL LABORATORY FOR TESTING SPACE FLIGHT HARDWARE AT THE  
NASA GLENN RESEARCH CENTER**

Beth A. Cooper

NASA John H. Glenn Research Center at Lewis Field  
21000 Brookpark Road M.S. 86-10  
Cleveland, Ohio 441135

**INTRODUCTION**

The NASA John H. Glenn Research Center at Lewis Field has designed and constructed an Acoustical Testing Laboratory (ATL) to support the low-noise design of microgravity space flight hardware. This new laboratory provides acoustic emissions testing and noise control services for a variety of customers, particularly for microgravity space flight hardware that must meet International Space Station (ISS) limits on noise emissions.

The ATL provides a comprehensive array of acoustical testing services, including sound power level testing per ANSI S12.34 and ANSI S12.35. A multichannel PC-based acoustical data acquisition system allows simultaneous acquisition and real-time analysis of signals to facilitate the identification of equipment noise sources and transmission paths. Although ATL functions as a design verification facility by producing data to document requirements compliance, it was constructed primarily to provide an in-house laboratory environment where noise control design strategies are actively pursued and integrated into the overall design of flight hardware, early in the life of each project.

**ACOUSTICAL TESTING LABORATORY DESIGN GOALS**

Science experiment payloads that will reside on the International Space Station are subject to acoustic noise emission requirements, which have been imposed by ISS to support hearing conservation, speech communication and safety goals as well as to prevent noise-induced vibrations that could adversely impact microgravity research data. These requirements include meeting an NC-like maximum sound pressure level criterion spectrum for acoustic emissions (the exact spectrum depends on the nature of the payload and its intended operational characteristics) as well as conducting sound power level testing in accordance with any of several published standards.

Although ISS policies require the above testing for final verification and compliance purposes, the primary motivation for the design and construction of the Acoustical Testing Laboratory at Glenn Research Center was the need for an accessible, secure and flight-hardware-compatible acoustical testing environment that would virtually *ensure* compliance by facilitating the successful implementation of low-noise payload design strategies.

The ATL was designed as a reconfigurable hemi/anechoic chamber in order to be able to meet either ANSI S12.34 or ANSI S12.35 (or both) for typical experiment payloads up to a full rack in size (approximately 3-ft. by 3-ft. by 6-ft. (h)). Vibration isolation and very low background and self-noise levels were dictated by the need to acquire accurate and repeatable acoustic emission measurements on the least-noise-producing component of a payload, typically a small fan.

Most larger payloads, especially full racks that serve as permanent on-orbit test beds for a succession of payloads by providing common utilities and service connections, usually require the operation of test support equipment in order to generate noise under ground-based laboratory conditions. It is necessary to prevent noise generated by this support equipment, which can include high-noise items such chillers, pumps and power supplies, from contaminating acoustical measurements of the experiment itself. As a result, the support equipment must be located in a remote, noise-attenuating enclosure with the capability of running service hoses and cables between the test support enclosure and test chamber to permit operation and control of the test article without any attendant acoustical leaks between the two rooms.

## **DESCRIPTION OF FACILITY CAPABILITIES**

The Acoustical Testing Laboratory consists of a test chamber with 27-ft. by 23-ft. by 20-ft. (h) outside dimensions (21-ft. by 17-ft. by 17-ft. (h) interior working dimensions) and separate sound-attenuating test support enclosure with outside dimensions of 23-ft. by 11-ft. by 12-ft. (h). The ATL is located, along with two other engineering verification facilities, inside a pre-engineered host building with dimensions of 50-ft. by 150-ft. by 35-ft. (h). The host building provides the ATL with a conditioned exterior environment, overhead crane support and utility services such as chilled water and shop (compressed) air.

**Test Chamber Design.** Constraints on the available space in the host building dictated a smaller chamber than would have allowed full anechoic testing of the largest test articles per ANSI S12.35. Therefore, the capability of configuring the chamber as either anechoic or hemianechoic was incorporated into the design to ensure that even the largest test articles would fall within the applicability of either ANSI S12.34 or ANSI S12.35. This is accomplished with removable floor wedges mounted in rolling carts. The chamber design was tailored to support reconfigurability by employing horizontally-split doors and a set of personnel access steps built into one of the floor wedge carts. Removable modular expanded-metal grating sections attached to each floor wedge cart provide a walking surface above the wedge tips.

In the test chamber, fiberglass wedges with an overall treatment depth of 34-in. provide an anechoic environment with a low frequency cutoff of 100 Hz. The wedges are faced with 22 ga perforated metal with a 53% open area. An above-grade spring-isolated floor system affords vibration isolation above 3 Hz. for test articles with a maximum weight of 5000 lbs. Snubbers below the 6-in. concrete slab allow an 8000-lb. forklift truck to safely maneuver test articles into position.

Low background noise levels required for accurate acoustical measurements are afforded by pre-fabricated 4-in. thick wall panels with an internal septum, which provide noise reduction, rated at STC 54, between the host space and the test chamber. A silenced two-speed stand-alone ventilation system with 50% efficiency filtering provides conditioned air from the host space.

To permit equipment access, the test chamber has one set of 9-ft. by 10-ft. (h) double doors as well as a removable 8-ft. by 8-ft. panel in the ceiling that may be lifted by crane. A personnel door functions as an emergency egress exit. When the chamber is configured in the full anechoic mode, a set of portable steps is positioned on the exterior of the chamber during laboratory operations to permit entrance/egress between the walking surface above the floor wedges (approximately 38-in. high) and grade level in the host building.

A “very early” smoke detection system continuously samples air in the test chamber and the test support enclosure and notifies a central lab-wide monitoring/dispatch station of any threshold exceedances.

**Test support enclosure design.** The test chamber and adjacent test support enclosure are physically and acoustically separate structures located on either side of a 4-in. air space filled with fiberglass insulation. For most test programs, the test support enclosure functions as a control room and houses acoustic data acquisition and customer test control equipment. The test support enclosure, therefore, is also a pre-fabricated room with 4-in. thick wall and ceiling panels rated at STC 49. Silenced (rated at NC 25) and filtered (30% efficiency) two-speed ventilation and absorptive interior wall/ceiling panel surfaces provide the office-like environment appropriate for most operations. The ventilation system is separate from both the host building system and the stand-alone system that serves the test chamber.

For test programs where the test article requires remotely-located test support equipment whose noise emissions could contaminate the acoustical signals being measured in the test chamber, the test support enclosure functions as a noise control enclosure. In this case, the acoustical data acquisition and customer test control equipment and functions are relocated to the hallway outside the test support enclosure by means of rolling equipment carts and movable modular furnishings. Electrical receptacles on the exterior walls of the chamber and test support enclosure facilitate easy reconfiguration of the test control and data acquisition setup. The floor of the test support enclosure is located at grade, enabling equipment to be moved in and out easily through a set of 8-ft. by 10-ft. (h) double doors.

Test support equipment located in the enclosure is powered by 120V AC or 208V 3-phase electrical service supplied in the control room and, in turn, provides services to the test article in the chamber via temporary customer-supplied hoses, cables, and tubing that pass through silenced utility sleeves in the walls of the two rooms. Utility sleeves in the other walls allow phone, Ethernet, shop air and water services to be temporarily supplied to the test support enclosure from the host building and also allow these services as well as data/control functions to be routed, when required, to the alternate test control location in the adjacent hallway. Video and intercom systems facilitate remote test operation as well as communication between the chamber and other locations during setup and testing.

Personnel traffic between the test chamber and test support enclosure must pass through a series of two aligned doors, one in each of the rooms. A set of steps recessed into the floor wedge cart located immediately inside the chamber provides a means of navigating the change in elevation between the floor of the test support enclosure and the test chamber walking surface above the floor wedges.

## **SUMMARY**

At the NASA Glenn Research Center, science experiment payloads developed for the International Space Station are designed to meet noise emission criteria that promote hearing conservation and speech intelligibility goals. A key component in the successful design of low-noise hardware is the frequent use of acoustical testing as a diagnostic and design verification tool. NASA has designed and constructed a convertible hemi/anechoic Acoustical Testing Laboratory that provides convenient access to accurate and repeatable sound pressure level measurements as well as state-of-the art capabilities for sound power level testing per ANSI S12.34 and ANSI S12.35 using a multichannel PC-based data acquisition system.

The ATL consists of a 100 Hz. hemi-anechoic chamber, vibration-isolated to 3 Hz., with 21-ft. by 17-ft. by 17-ft. (h) interior working dimensions and removable floor wedges that allow the facility to be configured as either a hemianechoic or fully anechoic chamber. These characteristics, along with very low design background levels, enable the acquisition of accurate and repeatable acoustical measurements on test articles, up to a full ISS rack in size, that produce very little noise. A separate, sound-isolated control room doubles as a test support equipment enclosure when testing articles that require remote connections to high-noise support equipment and services. Movable modular furnishings facilitate reconfiguration of the enclosure so that data acquisition and test control functions may be easily relocated to an adjacent quiet area.

The Glenn Research Center Acoustical Testing Laboratory provides testing services for microgravity space flight hardware developed by NASA and external contractors as well as for commercial products and other non-NASA hardware. The ATL also offers a full range of noise control services to assist payload developers with meeting the ISS noise emission criteria.

## **REFERENCES**

Pressurized Payloads Interface Requirements Document, International Space Station, National Aeronautics and Space Administration, SSP 57000 Revision E, April 21, 2000

American National Standard Engineering Methods for the Determination of Sound Power Levels of Noise Sources for Essentially Free-Field Conditions over a Reflecting Plane, ANSI S12.34-1988 (R1997)

American National Standard Precision Methods for the Determination of Sound Power Levels of Noise Sources in Anechoic and Hemi-Anechoic Rooms, ANSI S12.35-1990 (R1996)